

the pumping station show that it furnishes an average of about 35,000 gallons a day, and that on certain days it is required to furnish as much as 60,000 gallons, which, however, approaches its maximum capacity, especially in dry seasons.

In Mount Ayr a well was at one time sunk for the municipality to a depth of about 300 feet, where a water-bearing bed of sand was discovered. Because of difficulty with the sand or for some other reason, this well was never finished.

UNION COUNTY.

BY HOWARD E. SIMPSON.

TOPOGRAPHY.

Union county lies on that branch of the great divide that separates the southeasterly flowing waters of Grand river from those which flow southwesterly through the branches of Platte and East Nodaway rivers. The crest of the divide runs southward through Spaulding and Creston. At Creston the Chicago, Burlington & Quincy railroad attains an elevation of 1,312 feet, a rise of 261 feet from Afton Junction. By a peculiar adjustment of the drainage lines the entire run-off passes into the Missouri—that of the eastern slope through Grand river and that of the narrower western slope through Platte and East Nodaway rivers.

The surface is a slightly rolling drift plain. Maturity is shown by the absence of ponds and undrained areas, by the completeness of the drainage, and by the presence of the numberless small intermittent tributary streams. On the east, especially about Afton Junction, the plain is more dissected and broken.

GEOLOGY.

The country rock beneath the surface of the county belongs to the Missouri stage of the Pennsylvanian series, and consists chiefly of limestones, shales, and some beds of sandstone and seams of coal. Above these rocks, though separated from

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them by an unconformity indicating the lapse of a very long period of time, lie the loose, unconsolidated deposits of clay, sand, gravel, and boulders known as the drift. This averages from 100 to 250 feet in thickness and is chiefly of Kansan age. Beneath the Kansan till, and separated from it by a heavy bed of gravel known as the Aftonian, from its discovery in the railway cuts west of Afton Junction, is an earlier till known as the Nebraskan drift. That this older drift is present throughout the greater portion of the county at least is shown by the presence within the drift of a very persistent gravel bed corresponding to the Aftonian, by the presence of old forest or soil deposits, and by peculiarities of the basal till, showing differences in composition and age.

Above the drift everywhere except on the bottoms of the deeper valleys lies the light yellow plastic clay, known as the loess. It is generally free from pebbles, but contains numerous white calcareous concretions. Widely associated with the lower layers of the loess is a sticky, black plastic clay called gumbo.

In all stream valley bottoms a deposit of alluvium has been formed, chiefly from the wash of the loess, gumbo, and drift. The alluvium is thinner and of less importance in Union county than in other counties of southwestern Iowa that are farther from the divide.

UNDERGROUND WATER.

SOURCES.

The chief shallow-water beds of the county are the alluvium, the loess, the Kansan till, the Aftonian gravel, the Nebraskan, and the limestone of the Missouri stage. All of these except the Aftonian gravel, which is one of the best aquifers in Iowa, are frequently unsatisfactory or insufficient.

Sufficient quantities of sand interstratified with silt are found in the alluvium of some of the larger tributaries of the Grand, in the southeastern portion of the county, to allow the use of drive-point wells, which, however, are not common.

The seepage at the base of the loess, especially where it overlies gumbo, supplies many shallow wells for domestic use, but the quantity is meager and uncertain.

The upper portion of the Kansan till usually contains much gravel and sand and these frequently supply sufficient water for many shallow wells, so that this horizon, together with the sandy base of the loess, is known as the "first water." A few wells find sand pockets in the Kansan till; the water from these is excellent in quality but is very variable in quantity, frequently failing altogether in dry seasons.

The Aftonian gravel, lying between the two till sheets, forms the best aquifer of this portion of the state, and its water is generally known on the uplands as the "second water." It is usually pure, wholesome, and abundant. In the valleys, owing to the absence of loess, the Aftonian is in many places the first water bed reached. The depth to it ranges from 30 to 200 feet. Wherever the gravel outcrops it forms a horizon of strong springs. A good illustration is found on the farm of John Leininger, 2½ miles north of Afton, where a powerful permanent spring flows from the base of a hill in which the gravel outcrops. In some places water from the Aftonian is rendered disagreeable and impotable by the presence of decaying organic matter of old soil, peat, and forest beds.

A "third-water" horizon is found in beds of sand and gravel in the base of the Nebraskan drift, immediately above the bedrock. This usually lies at depths of 100 to 200 feet, but its occurrence is uncertain; probably in many places the Aftonian gravel rests immediately on the bedrock.

The country rock, composed as it is of thinly bedded limestone and calcareous shales, is not a good water carrier, its supply being small and its water hard and locally mineralized. The great thickness of the drift also makes it an expensive source of supply, and it is not resorted to when it is possible to obtain water from the upper beds. If the supply is insufficient after deep drilling, it is advisable, before abandoning the well, to try "shooting" with nitroglycerin and puncturing the capings opposite higher beds, in order to combine the supplies. Because of the scarcity of good ground water at ordinary depths on the higher uplands of the county about Creston and Spaulding, many of the larger stock farms resort to ponded storm waters.

is apparently another
fairly good domestic water from shallow
quaternary deposits

The following composite section, from descriptions given by well men, shows the relations of the several water beds:

Composite well section about Creston.

	Thickness in feet.
Soil, black.....	1-3
Loess; light yellow clay containing calcareous concretions.....	10-20
Kansan till:	
Yellow gravelly clay, containing numerous sand and gravel beds; water bearing (first water).....	2-6
Blue bowlder clay, compact and hard.....	20-100
Aftonian; sand and gravel, yellow and coarse; heavily water bearing (second water).....	2-6
Nebraskan till:	
Yellow, hard and gravelly.....	10-20
Blue and black, pebbles, and bowlders.....	20-40
Sand and gravel, water bearing (third water).....	2-4
Shaly limestone.	

The upper portion of the Aftonian in many wells shows soil, peat, or forest beds, and the upper portion of the shaly limestone at the base of the section is often broken into a coarse rubble, mingled with residual gravel and soil and characteristic gneiss. The thickness of the drift at Creston is reported to be 260 feet.

SPRINGS.

Strong springs are numerous along the valley sides in the broken portion of the country. The Aftonian gravel, lying as it does between the till sheets, supplies one of the best spring horizons in Iowa. Little use is made of these springs, however, except as stock water, and even then they are rarely walled up and piped, but are simply permitted to flow, forming more or less of a bog in many cases.

CITY AND VILLAGE SUPPLIES.

Afton.—The public supply of Afton (population, 1,014) consists of five wells on the town square, ranging from 25 to 40 feet in depth. All are likely to fail in summer, except the 40-foot well, which usually contains 20 feet of water and is permanent.

A well at the creamery, in the northwestern portion of the town, is 365 feet in depth and reaches bedrock at 173 feet. It obtained abundant water in a gravel and sand layer in the drift a few feet above bedrock. The water was too hard for boiler use. Later the well was abandoned on account of clogging by mud and fine sand. The log follows.

Log of creamery well at Afton.

Thickness, Depth.	
Feet	Feet
Clay, yellow, and soil	50
Clay, blue	115
"Sandstone" (probably cemented sand and gravel)	4
Sand and gravel, fine	1
Mud, blue and black	2
Shale and "sopstone"	181
Limestone, hard	285

An important deep well is that of C. C. Boys (SE. ¼ sec. 11, T. 72 N., R. 30 W.). This well is 671 feet deep and was originally drilled as a coal prospect hole. No good section or log can be obtained, but it is known that bedrock was reached at 116 feet and the most important water bed found in a 10-foot bed of sand and gravel 46 feet above this, probably in the Aftonian. This was cased out until the prospect hole was finished; it was then opened up for a well, which has furnished a large and permanent supply.

supplied with water
shallow prospect
no more of the creek
Creston.—The public supply of Creston (population, 6,924) is drawn from an artificial lake about two miles long, about one-half mile wide, and 30 feet deep. Similar though smaller ponds are used by many farmers about Creston to assure a stock supply in summer.

Minor supplies.—Most villages are supplied from shallow wells 15 to 20 feet deep. About Afton Junction, Talmage, and Thayer the Aftonian gravel lies within comparatively few feet of the surface.

WARREN COUNTY.

BY JOHN L. TILTON.

TOPOGRAPHY.

The upland of Warren county is a well-dissected plain sloping from 1,088 feet above sea level in the southwestern portion to 900 feet in the northeastern portion. It is drained chiefly by three streams, North, Middle, and South rivers, that flow toward the northeast, with tributaries extending back to all portions of the upland.

GEOLOGY.

The Des Moines stage with its shale, sandstone, and coal underlying all sections of the county, extends from near the surface to a depth of 250 to 300 feet. (See Pl. XVI, p. 814.) In a few square miles only in the western half of Virginia township the Missouri stage with its limestone and shale overlies the Des Moines. Between these Carboniferous strata and the overlying Pleistocene lies a thin deposit of subglacial sand and old soil, remnants of the old surface prior to the advent of the Nebraskan ice sheet.

The Nebraskan drift is a tough, impervious, bluish black till containing pebbles of greenstone, white quartzite, and light colored granite. It is especially thick in the southern and western portions of the county, where the Kansan drift is thin. The sands and gravels (Aftonian) which overlie the Nebraskan drift, were largely derived from the erosion of this older till.

The Kansan drift is bluish black where not weathered and yellowish where weathered, containing here and there fine sand and minute pebbles. Among its numerous pebbles and boulders red quartzite and greenstone are common, together with dark decomposing granite. In some portions of the county the Kansan drift is but a few feet thick; in other places it measures at least 80 feet.

Union Co.

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